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Fluid migration and location of fractured layers in the crystalline basement by temperature logging in the Volga Region, Russia

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Abstract

High-precision temperature logging in deep and superdeep wells has permitted the study of the thermal regime in the granite–gneiss layer of the Earth's crust. The long-term logging works have allowed the classification of temperature anomalies recorded in the crystalline basement. Most anomalies have been supposed to be caused by loosely aggregated, permeable zones. The classification reflects main types of processes at a great depth — such as injection, inflow and upward migration of gas-cut fluid. The results of great practical importance are obtained using our classification: some intervals — where temperature anomalies interpreted as inflow reservoirs were revealed — have produced fluid, and others interpreted as injection reservoirs absorbed borehole fluid during tests.

Keywords: Temperature anomalies; Crystalline basement; Loosely aggregated zones; Fluid migration; Fluid injection and inflow

1. Introduction

High-precision temperature logging conducted in deep and superdeep wells after restoration of their thermal regimes has determined major thermal features of the crystalline basement and outlined its oil and gas prospects. Temperature logs from 686 deep wells of 153 oil and gas fields of the Volga region and 56 wells of 38 hydrocarbon areas of the neighboring regions have been used for imaging the temperature at depths up to 5800 m. The logged areas included oil and gas provinces of the Volga–Ural anteclise, Caspian trough, Ural foredeep, Moscow syneclise, Tokmovsky arch, Voronezh arch and others (Khristoforova et al., 1999, 2000).

Superdeep and deep wells drilled in the largest oil fields of Tatarstan are mainly aimed at reservoir location and hydrocarbons in the crystalline basement (Muslimov and Lapinskaya, 1996). Recent temperature data from the crystalline basement penetrated by the wells in 2004 and 2005 have confirmed the existing theory that the granite–gneiss layer of the Earth's crust is not monolithic. High-precision temperature surveys, geophysical logging and coring have all proved to be very consistent in locating the geothermal anomalies and fractured layers.

2. Temperature measurements in deep wells

In the granite–gneiss layer, minor temperature variations can imply the heterogeneous structure of the basement and the presence of loosely aggregated (LA) zones or shattering rocks that can be best detected by the high-precision temperature logging. The instruments

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